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4 / formal Drawings E. Willis 8-2-02

#4

S/N 10/077036

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Parker et al.	Examiner:	Unknown
Serial No.:	10/077036	Group Art Unit:	2881
Filed:	2/15/02	Docket No.:	**SJO919990205US1**
			501.314US01

Title: METHOD AND APPARATUS FOR COMPENSATING WAVEFORMS, SPECTRA, AND PROFILES DERIVED THEREFROM FOR EFFECTS OF DRIFT

CERTIFICATE UNDER 37 C.F.R. 1.8: The undersigned hereby certifies that this Transmittal Letter and the paper, as described herein, are being deposited in the United States Postal Service, as first class mail, with sufficient postage, in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on April 23, 2002

David W. Lynch
Name

Signature

SUBMISSION OF FORMAL DRAWINGS

Assistant Commissioner for Patents
Washington, D.C. 20231

22865
PATENT TRADEMARK OFFICE

Dear Sir:

Enclosed herewith are 26 sheet(s) of formal drawings for the above-referenced patent application in response to the communication dated April 1, 2002.

Respectfully submitted,

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952-253-4104

Date: April 23, 2002

By:
David W. Lynch
Reg. No. 36,204
DWL/vlb

#4

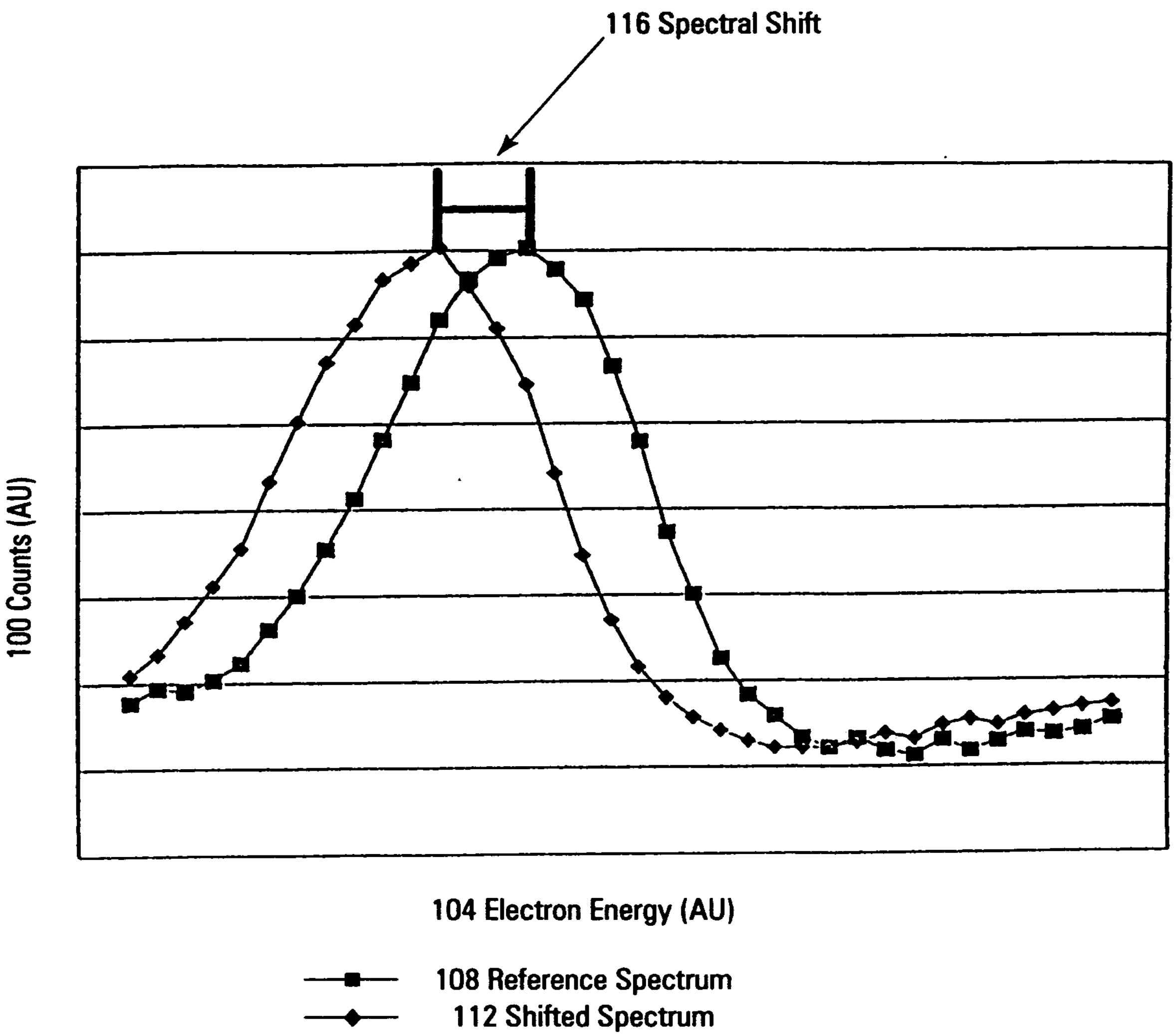


Fig. 1
(Prior Art)

Parker et al.
METHOD FOR REMOVING THE EFFECTS OF CHARGING FROM AUGER ELECTRON SPECTROSCOPY
AND ESCA COMPOSITION DEPTH PROFILES
SJO919990205US1 / 501.314US01

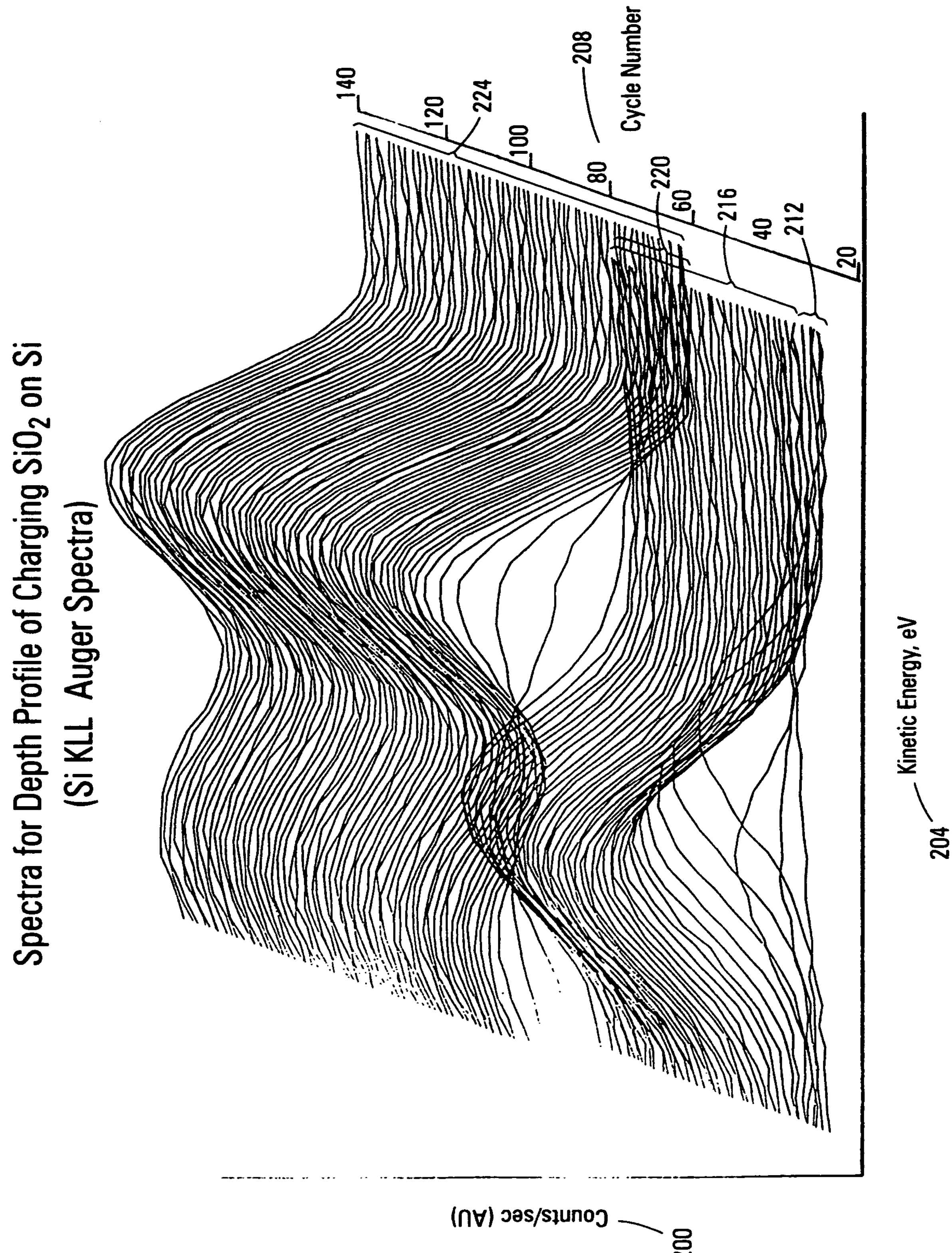


Fig. 2
(Prior Art)

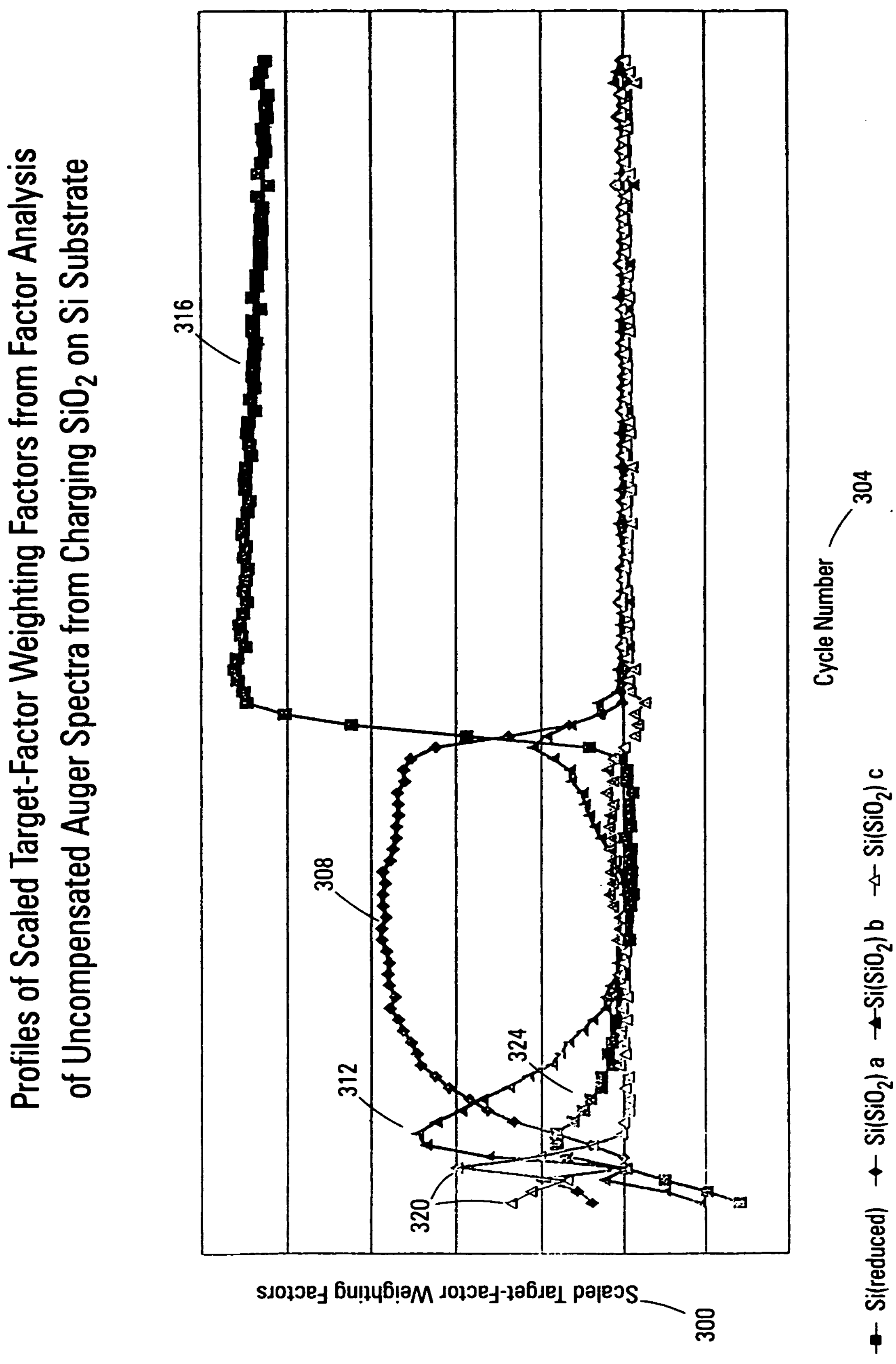


Fig. 3
(Prior Art)

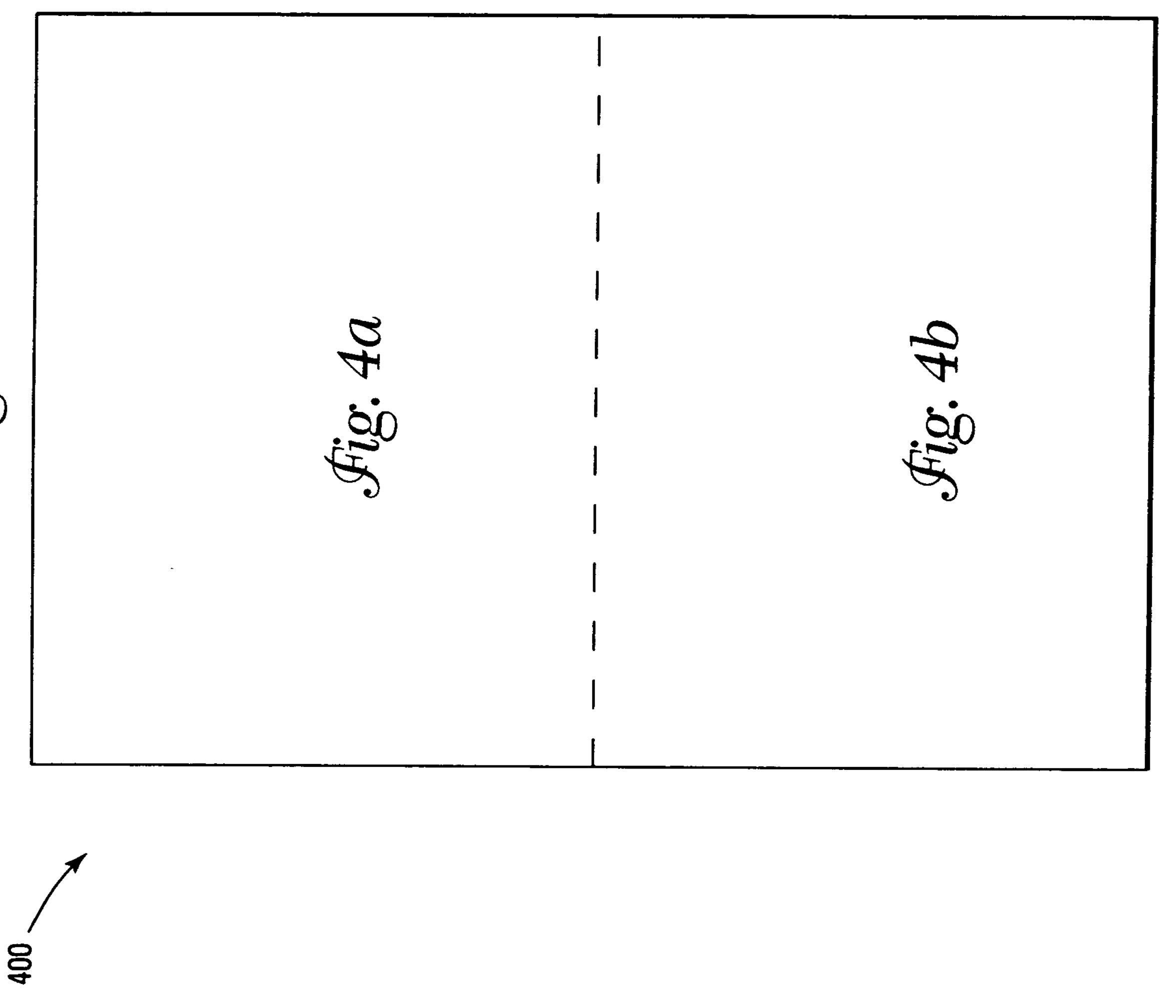
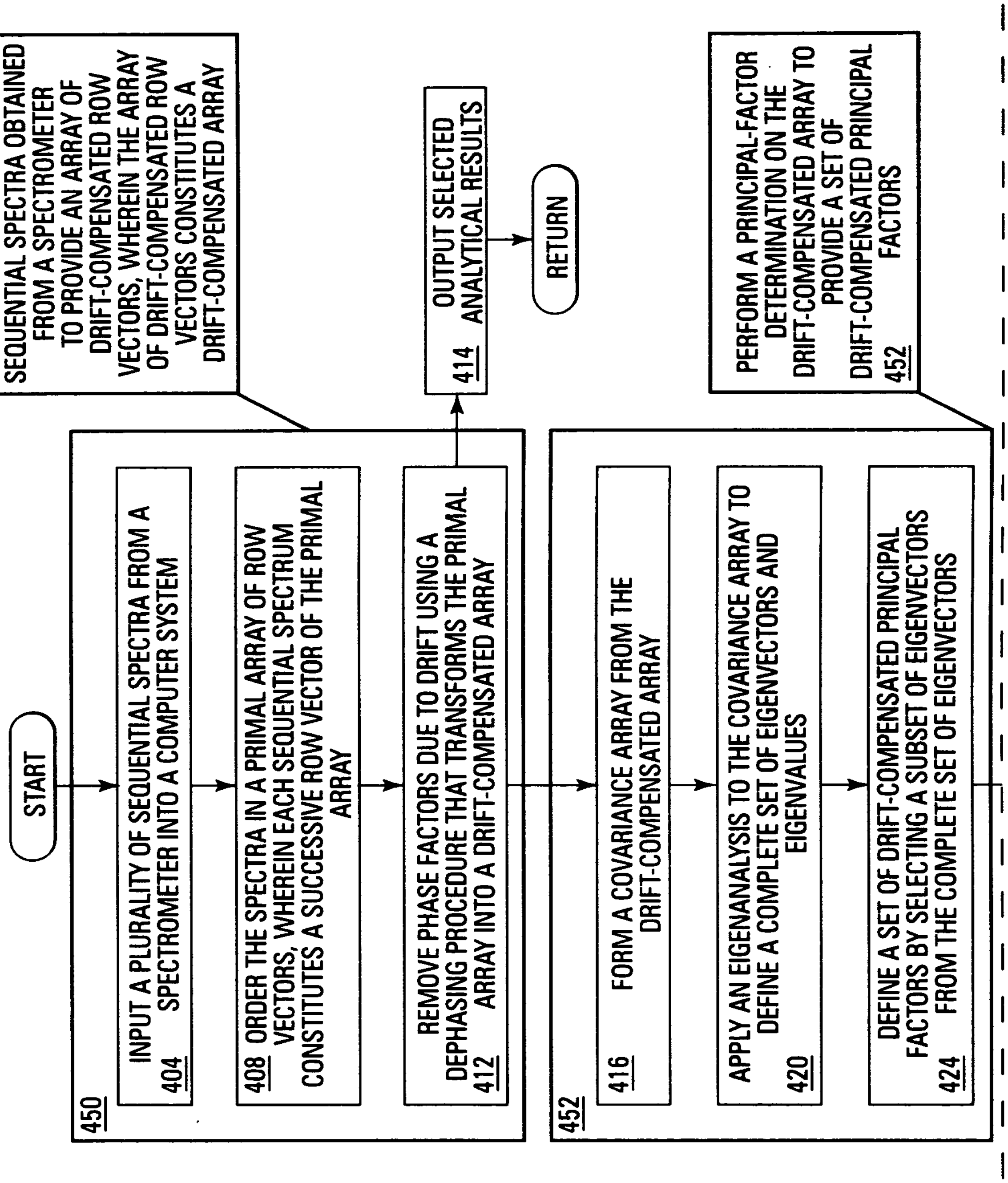


Fig. 4

Fig. 4a


START
450
404 INPUT A PLURALITY OF SEQUENTIAL SPECTRA FROM A SPECTROMETER INTO A COMPUTER SYSTEM
408 ORDER THE SPECTRA IN A PRIMAL ARRAY OF ROW VECTORS, WHEREIN EACH SEQUENTIAL SPECTRUM CONSTITUTES A SUCCESSIVE ROW VECTOR OF THE PRIMAL ARRAY
412 REMOVE PHASE FACTORS DUE TO DRIFT USING A DEPHASING PROCEDURE THAT TRANSFORMS THE PRIMAL ARRAY INTO A DRIFT-COMPENSATED ARRAY
450 TRANSFORM A PLURALITY OF SEQUENTIAL SPECTRA OBTAINED FROM A SPECTROMETER TO PROVIDE AN ARRAY OF DRIFT-COMPENSATED ROW VECTORS, WHEREIN THE ARRAY OF DRIFT-COMPENSATED ROW VECTORS CONSTITUTES A DRIFT-COMPENSATED ARRAY
414 OUTPUT SELECTED ANALYTICAL RESULTS
RETURN
452
416 FORM A COVARIANCE ARRAY FROM THE DRIFT-COMPENSATED ARRAY
420 APPLY AN EIGENANALYSIS TO THE COVARIANCE ARRAY TO DEFINE A COMPLETE SET OF EIGENVECTORS AND EIGENVALUES
424 DEFINE A SET OF DRIFT-COMPENSATED PRINCIPAL FACTORS BY SELECTING A SUBSET OF EIGENVECTORS FROM THE COMPLETE SET OF EIGENVECTORS
PERFORM A PRINCIPAL-FACTOR DETERMINATION ON THE DRIFT-COMPENSATED ARRAY TO PROVIDE A SET OF DRIFT-COMPENSATED PRINCIPAL FACTORS 452

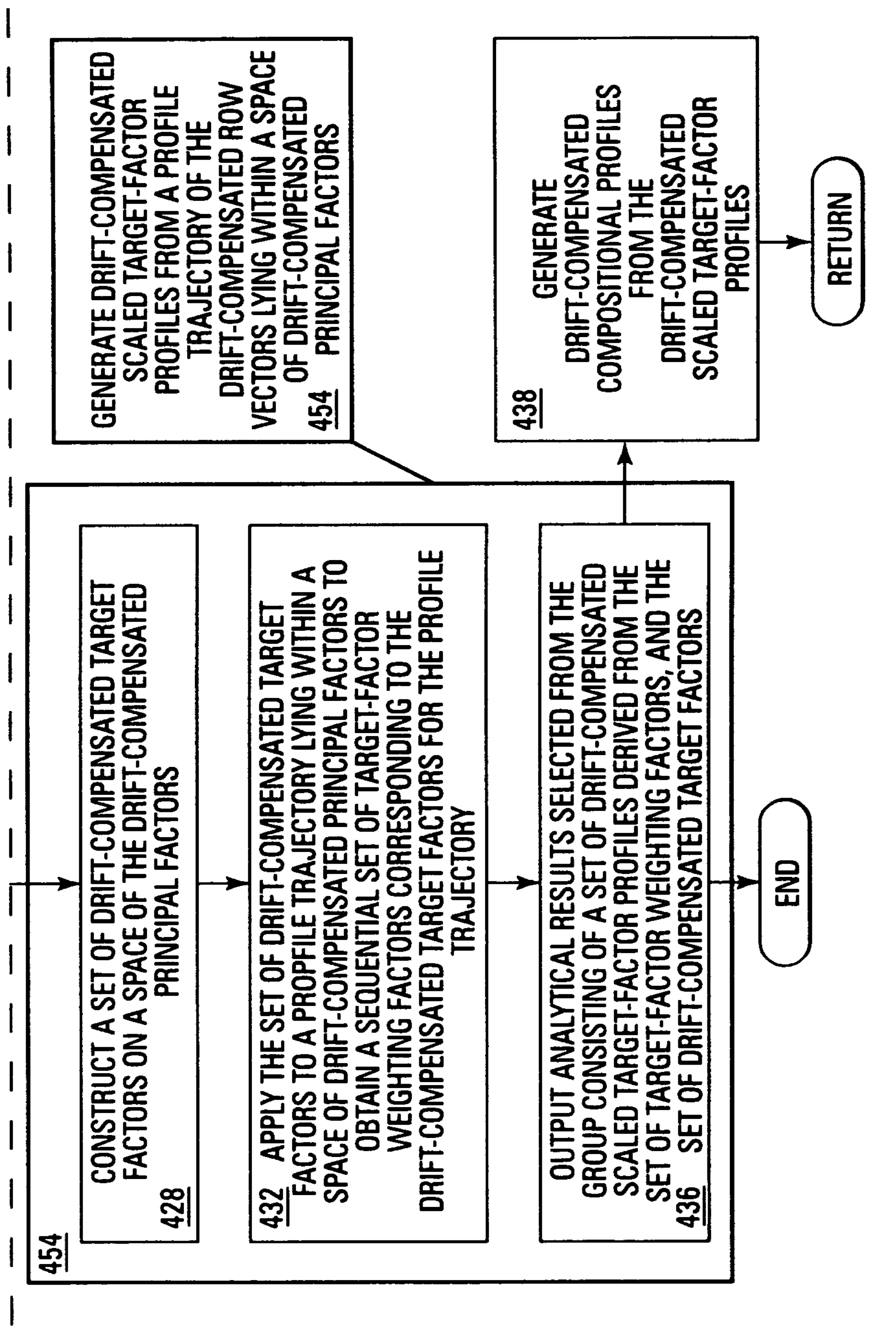

454
CONSTRUCT A SET OF DRIFT-COMPENSATED TARGET FACTORS ON A SPACE OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS 428
432 APPLY THE SET OF DRIFT-COMPENSATED TARGET FACTORS TO A PROPFILE TRAJECTORY LYING WITHIN A SPACE OF DRIFT-COMPENSATED PRINCIPAL FACTORS TO OBTAIN A SEQUENTIAL SET OF TARGET-FACTOR WEIGHTING FACTORS CORRESPONDING TO THE DRIFT-COMPENSATED TARGET FACTORS FOR THE PROFILE TRAJECTORY
OUTPUT ANALYTICAL RESULTS SELECTED FROM THE GROUP CONSISTING OF A SET OF DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES DERIVED FROM THE SET OF TARGET-FACTOR WEIGHTING FACTORS, AND THE SET OF DRIFT-COMPENSATED TARGET FACTORS 436
END
GENERATE DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES FROM A PROFILE TRAJECTORY OF THE DRIFT-COMPENSATED ROW VECTORS LYING WITHIN A SPACE OF DRIFT-COMPENSATED PRINCIPAL FACTORS 454
438 GENERATE DRIFT-COMPENSATED COMPOSITIONAL PROFILES FROM THE DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES
RETURN

Fig. 4b

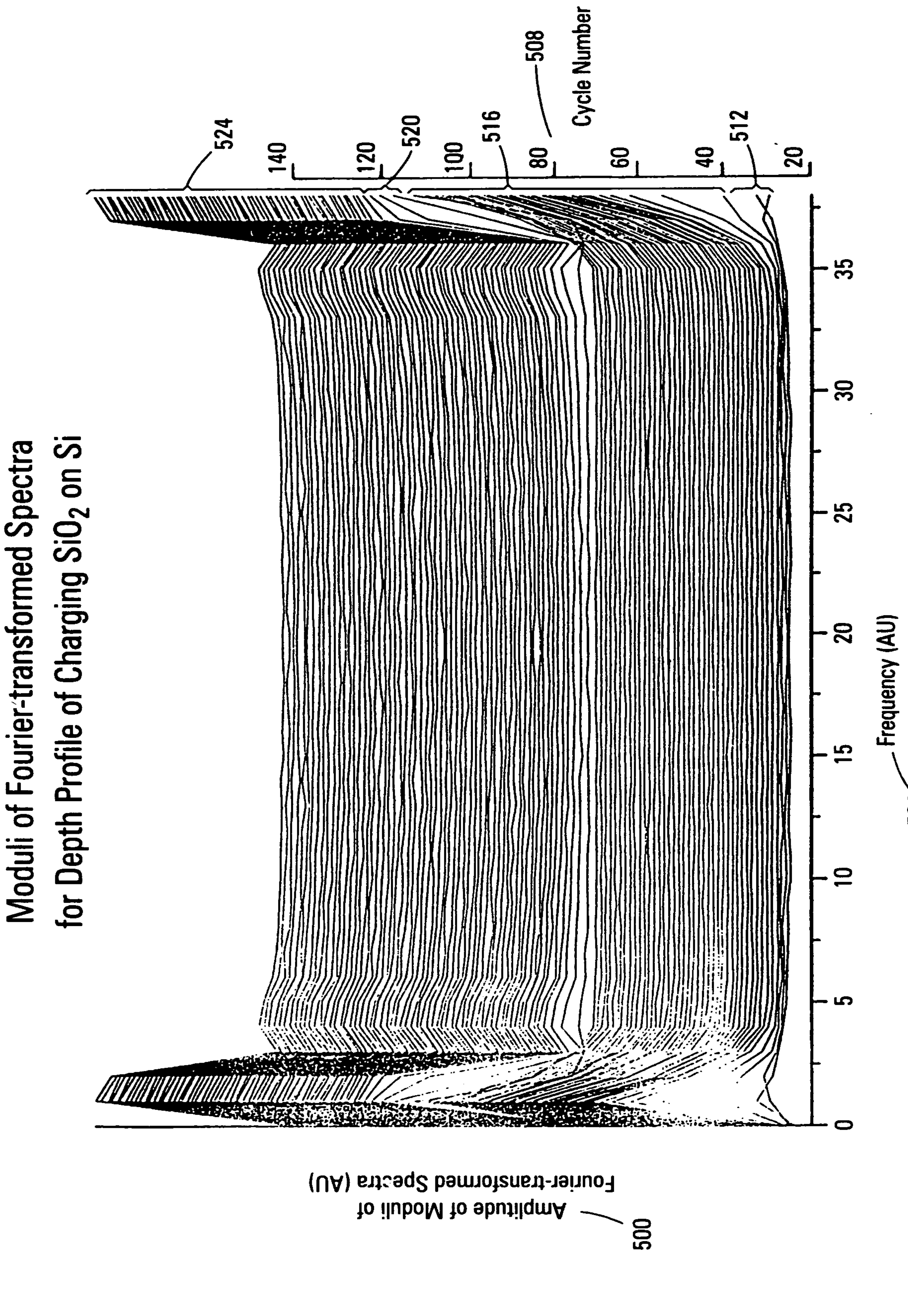

Moduli of Fourier-transformed Spectra
for Depth Profile of Charging SiO_2 on Si
Cycle Number
508
524
520
516
512
140
120
100
80
60
40
20
0
5
10
15
20
25
30
35
Frequency (AU)
504
Amplitude of Moduli of
Fourier-transformed Spectra (AU)
500

Fig. 5

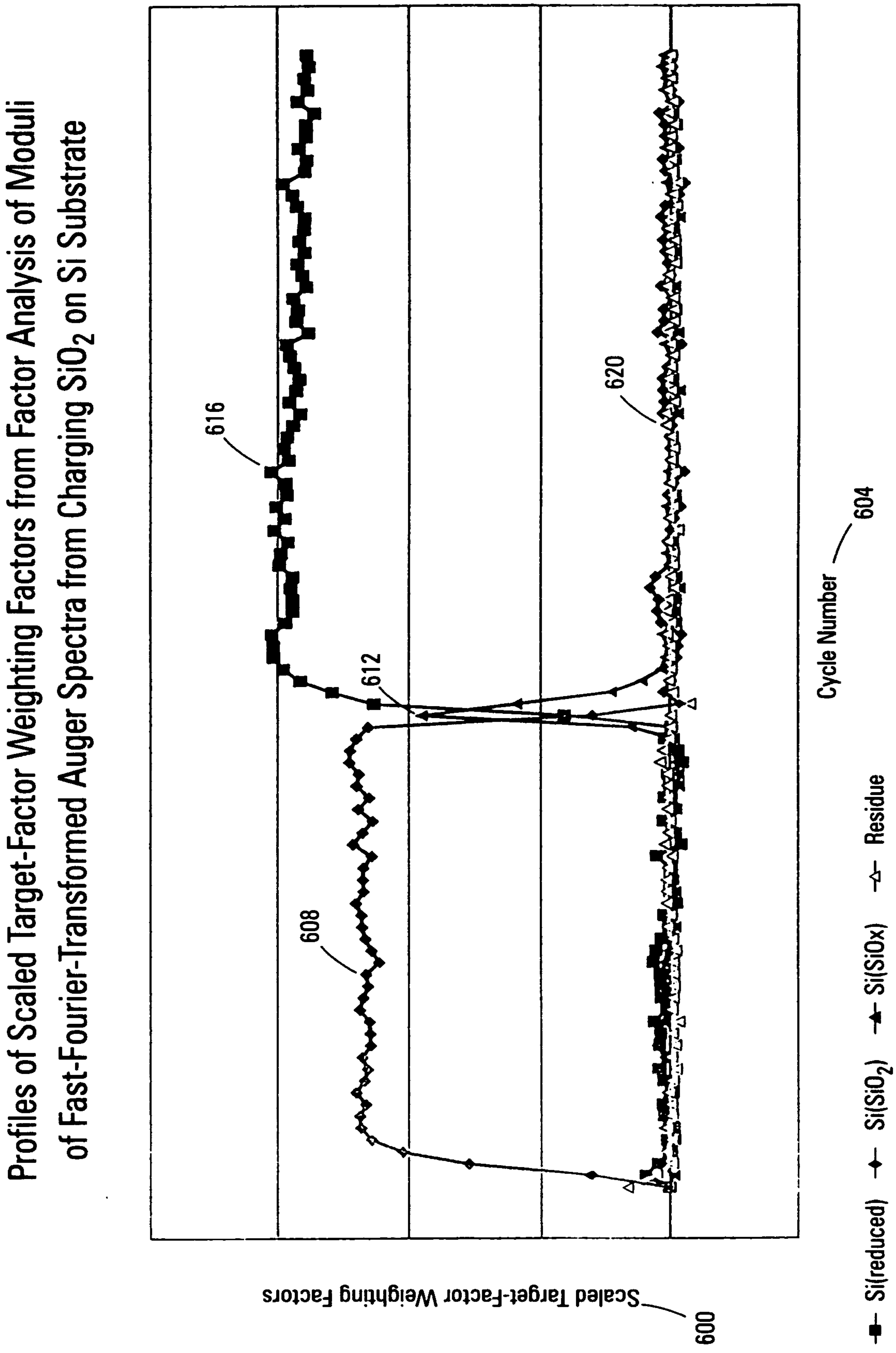

Profiles of Scaled Target-Factor Weighting Factors from Factor Analysis of Moduli
of Fast-Fourier-Transformed Auger Spectra from Charging SiO_2 on Si Substrate
616
620
612
608
Scaled Target-Factor Weighting Factors
600
Cycle Number
604
Si(reduced)
$Si(SiO_2)$
Si(SiOx)
Residue

Fig. 6

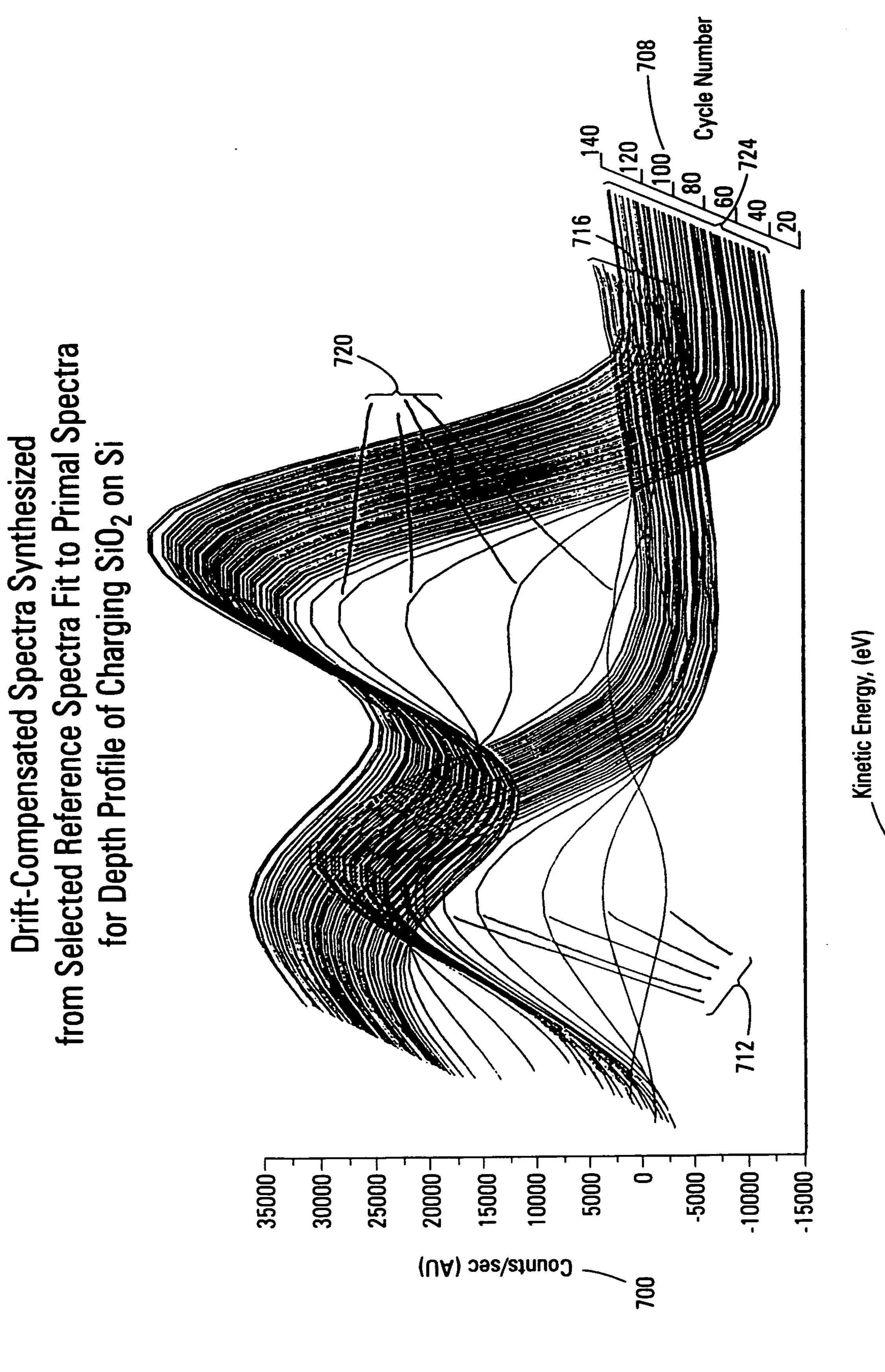

Drift-Compensated Spectra Synthesized
from Selected Reference Spectra Fit to Primal Spectra
for Depth Profile of Charging SiO_2 on Si
Counts/sec (AU)
700
35000
30000
25000
20000
15000
10000
5000
0
-5000
-10000
-15000
Kinetic Energy, (eV)
704
Cycle Number
708
140
120
100
80
60
40
20
724
716
720
712

Fig. 7

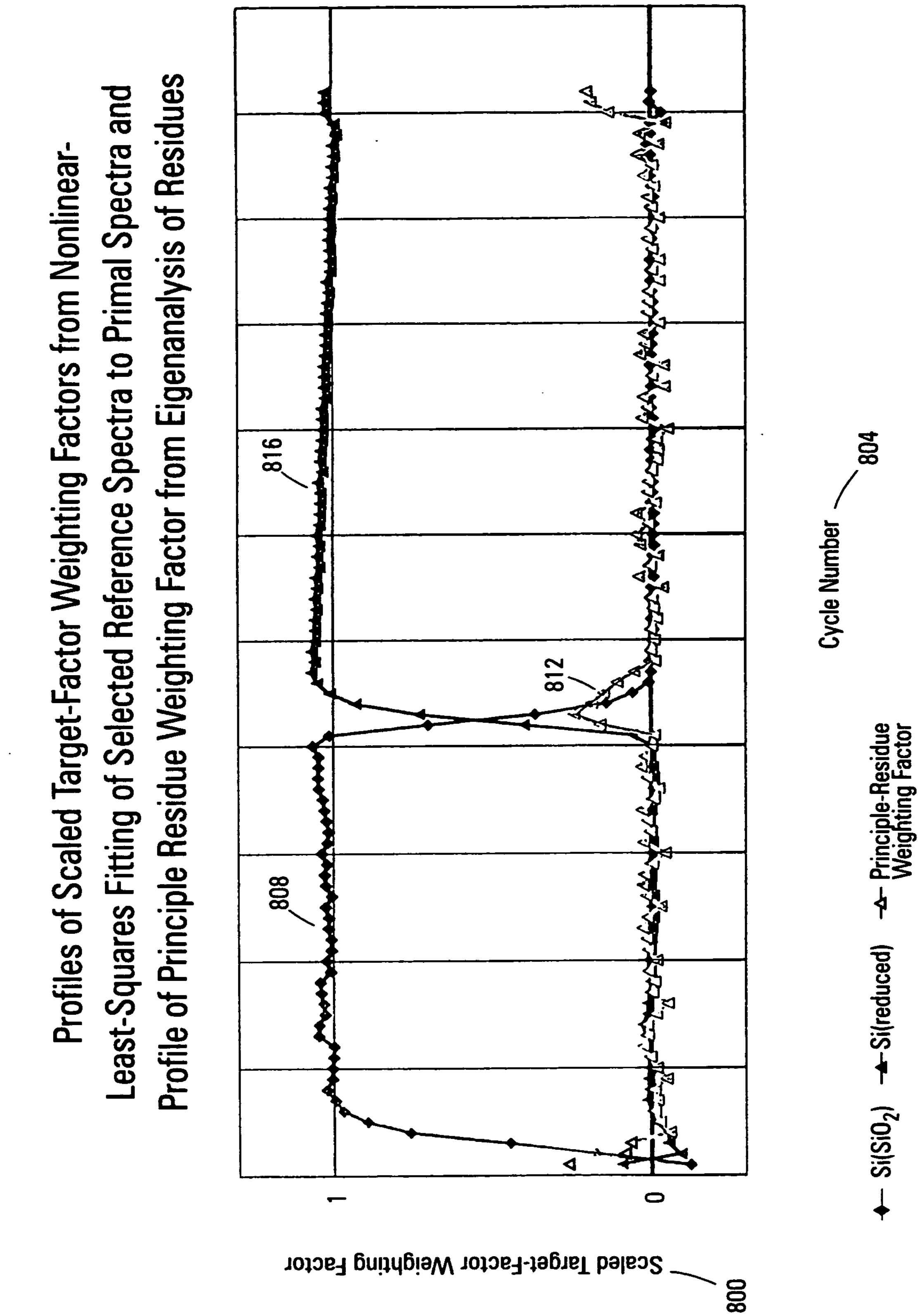

Profiles of Scaled Target-Factor Weighting Factors from Nonlinear-Least-Squares Fitting of Selected Reference Spectra to Primal Spectra and Profile of Principle Residue Weighting Factor from Eigenanalysis of Residues
808
816
812
1
0
Scaled Target-Factor Weighting Factor
800
Cycle Number
804
Si(SiO2)
Si(reduced)
Principle-Residue Weighting Factor

Fig. 8

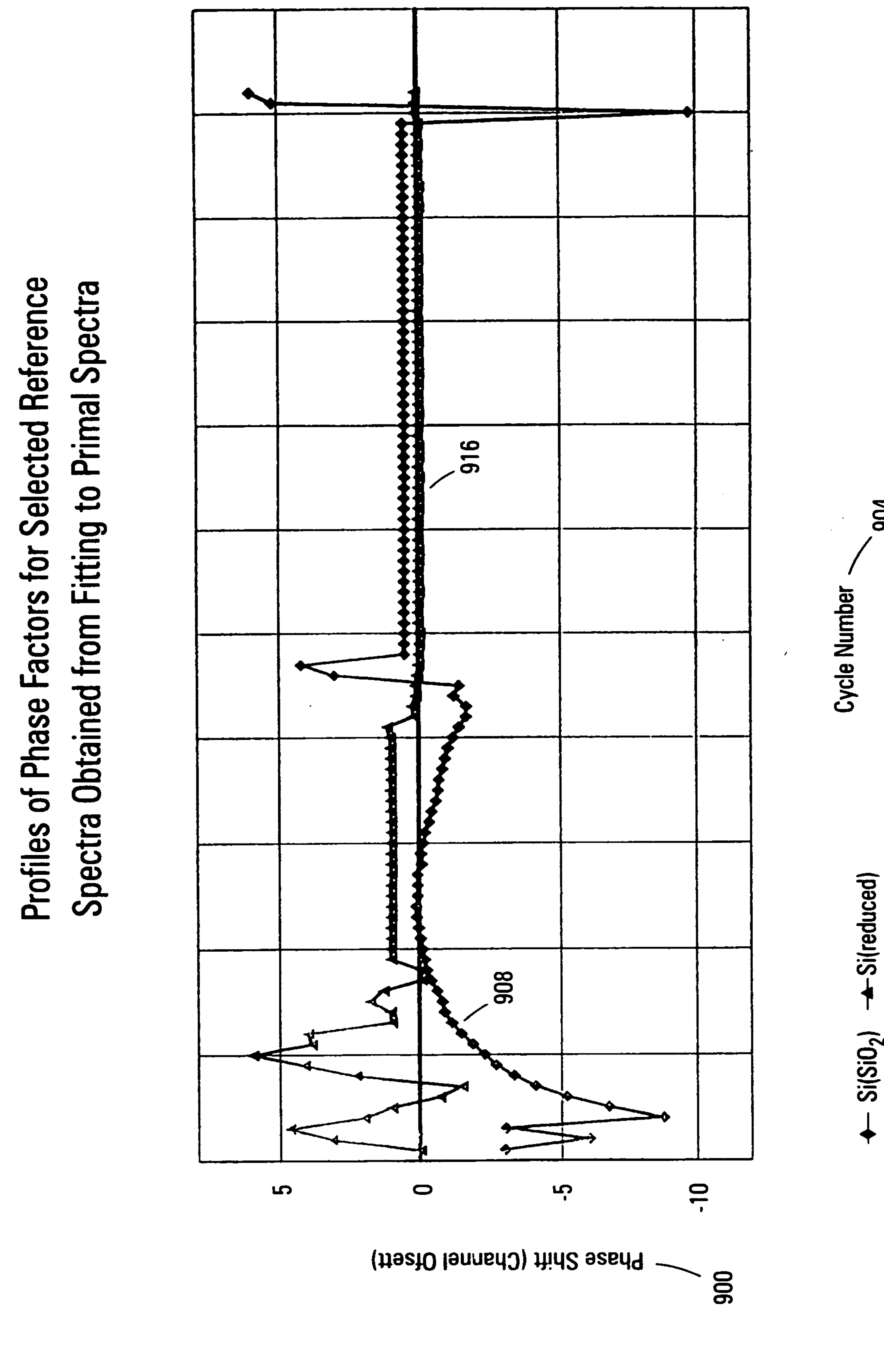

Profiles of Phase Factors for Selected Reference
Spectra Obtained from Fitting to Primal Spectra
Phase Shift (Channel Offset)
900
5
0
-5
-10
908
916
Cycle Number
904
Si(SiO2)
Si(reduced)

Fig. 9

REMOVE PHASE FACTORS DUE TO DRIFT USING A DEPHASING PROCEDURE THAT TRANSFORMS THE PRIMAL ARRAY INTO A DRIFT-COMPENSATED ARRAY
412

1000

412

1010 APPLY A FOURIER TRANSFORM TO THE SPECTRA IN THE PRIMAL ARRAY OF ROW VECTORS FORMING AN ARRAY OF FOURIER-TRANSFORMED ROW VECTORS

↓

1020 MULTIPLY EACH FOURIER-TRANSFORMED ROW VECTOR BY A COMPLEX CONJUGATE OF EACH FOURIER-TRANSFORMED ROW VECTOR TO FORM A SQUARED MODULI VECTOR THEREBY REMOVING PHASE FACTORS DUE TO DRIFT

↓

1030 TAKE THE SQUARE ROOT OF EACH ELEMENT OF THE SQUARED MODULI VECTOR TO CREATE A CORRESPONDING MODULI VECTOR

↓

1040 FORM A DRIFT-COMPENSATED ARRAY OF MODULI VECTORS BY SUCCESSIVELY SEQUENCING THE MODULI VECTORS AS SUCCESSIVE DRIFT-COMPENSATED ROW VECTORS IN A DRIFT-COMPENSATED ARRAY, WHEREIN THE MODULI VECTORS CONSTITUTE MODULI OF FOURIER-TRANSFORMED SPECTRA

Fig. 10

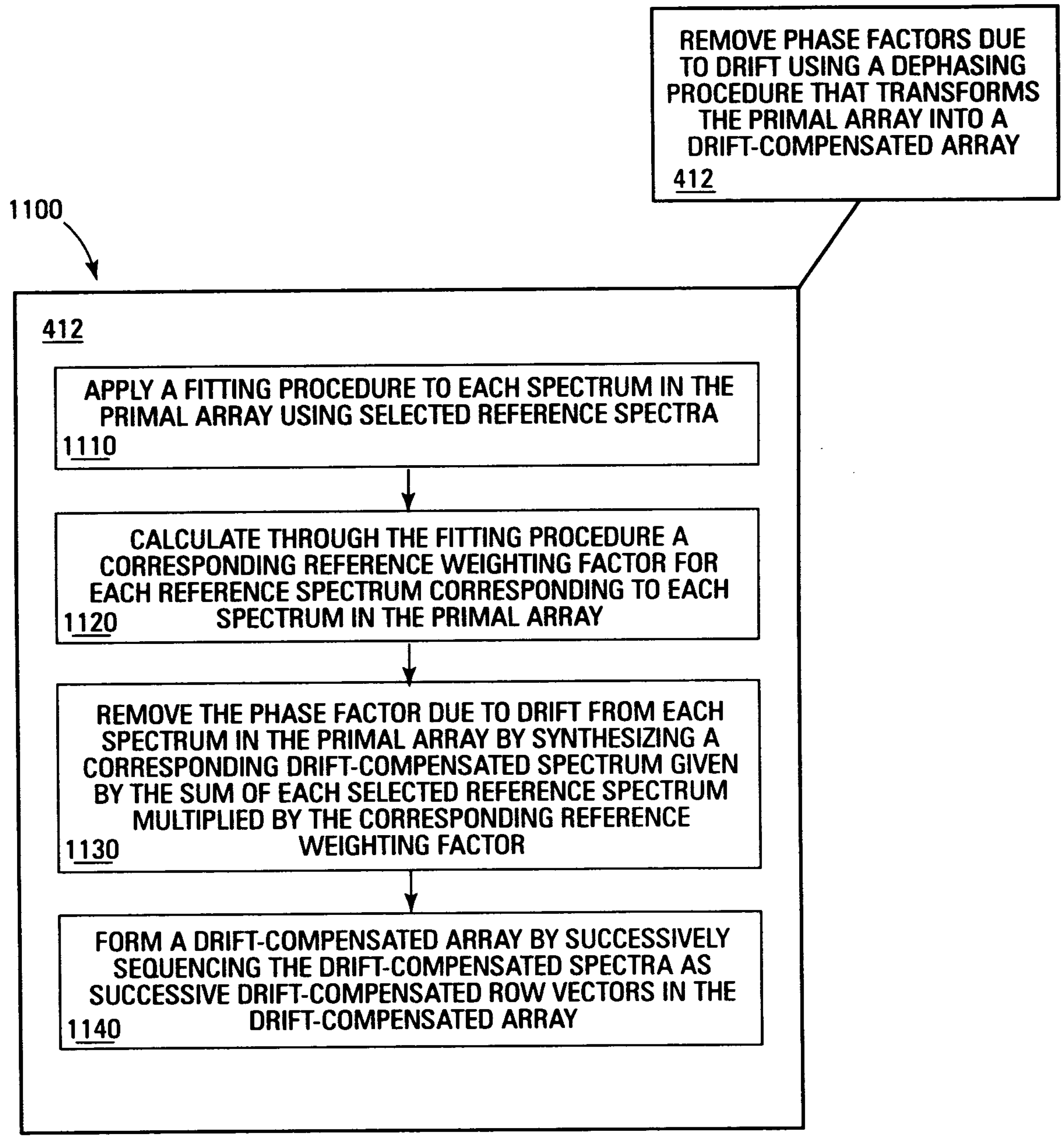

REMOVE PHASE FACTORS DUE TO DRIFT USING A DEPHASING PROCEDURE THAT TRANSFORMS THE PRIMAL ARRAY INTO A DRIFT-COMPENSATED ARRAY
412
1100
412
APPLY A FITTING PROCEDURE TO EACH SPECTRUM IN THE PRIMAL ARRAY USING SELECTED REFERENCE SPECTRA
1110
CALCULATE THROUGH THE FITTING PROCEDURE A CORRESPONDING REFERENCE WEIGHTING FACTOR FOR EACH REFERENCE SPECTRUM CORRESPONDING TO EACH SPECTRUM IN THE PRIMAL ARRAY
1120
REMOVE THE PHASE FACTOR DUE TO DRIFT FROM EACH SPECTRUM IN THE PRIMAL ARRAY BY SYNTHESIZING A CORRESPONDING DRIFT-COMPENSATED SPECTRUM GIVEN BY THE SUM OF EACH SELECTED REFERENCE SPECTRUM MULTIPLIED BY THE CORRESPONDING REFERENCE WEIGHTING FACTOR
1130
FORM A DRIFT-COMPENSATED ARRAY BY SUCCESSIVELY SEQUENCING THE DRIFT-COMPENSATED SPECTRA AS SUCCESSIVE DRIFT-COMPENSATED ROW VECTORS IN THE DRIFT-COMPENSATED ARRAY
1140

Fig. 11

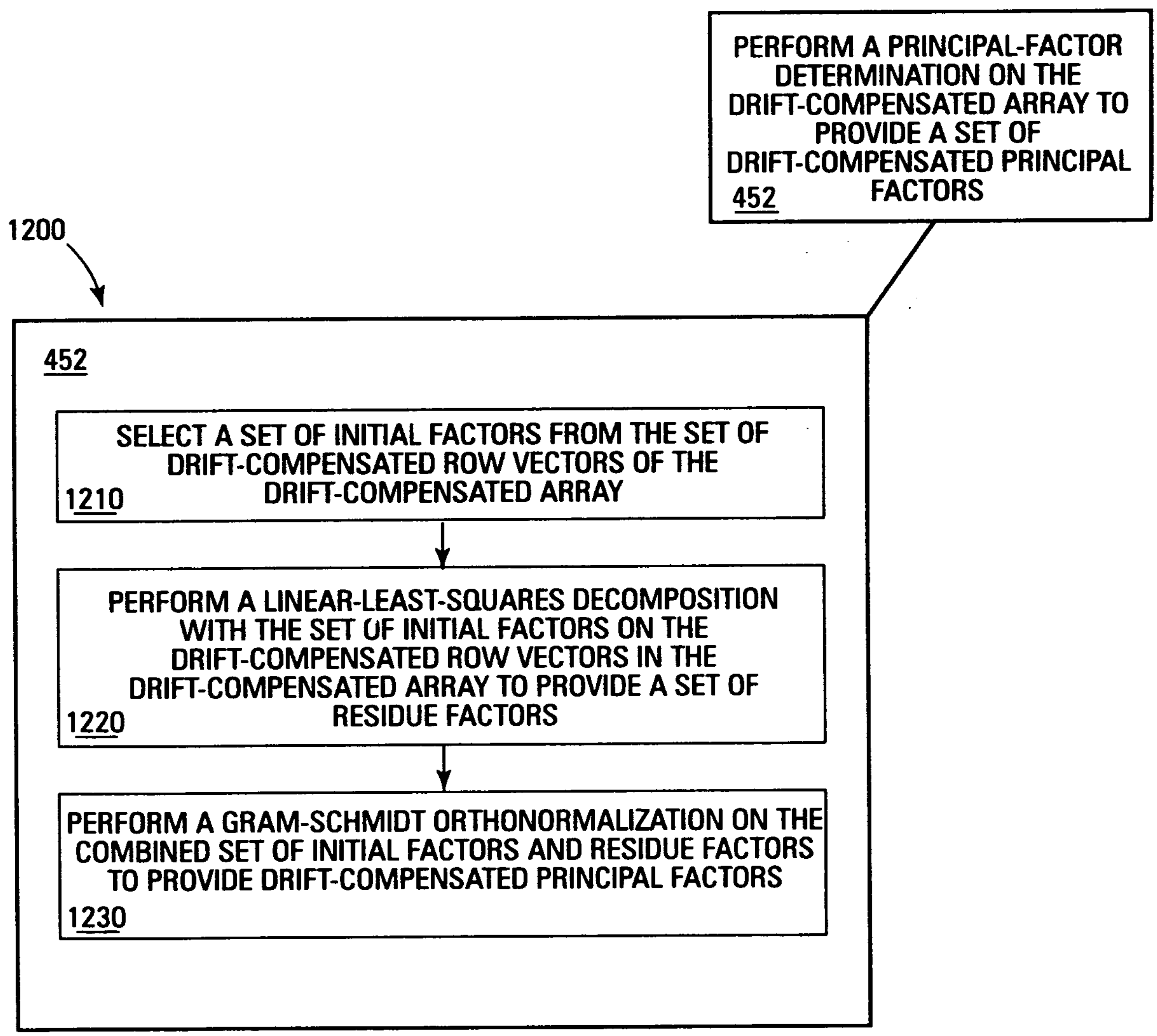

PERFORM A PRINCIPAL-FACTOR DETERMINATION ON THE DRIFT-COMPENSATED ARRAY TO PROVIDE A SET OF DRIFT-COMPENSATED PRINCIPAL FACTORS
452
1200
452
SELECT A SET OF INITIAL FACTORS FROM THE SET OF DRIFT-COMPENSATED ROW VECTORS OF THE DRIFT-COMPENSATED ARRAY
1210
PERFORM A LINEAR-LEAST-SQUARES DECOMPOSITION WITH THE SET OF INITIAL FACTORS ON THE DRIFT-COMPENSATED ROW VECTORS IN THE DRIFT-COMPENSATED ARRAY TO PROVIDE A SET OF RESIDUE FACTORS
1220
PERFORM A GRAM-SCHMIDT ORTHONORMALIZATION ON THE COMBINED SET OF INITIAL FACTORS AND RESIDUE FACTORS TO PROVIDE DRIFT-COMPENSATED PRINCIPAL FACTORS
1230

Fig. 12

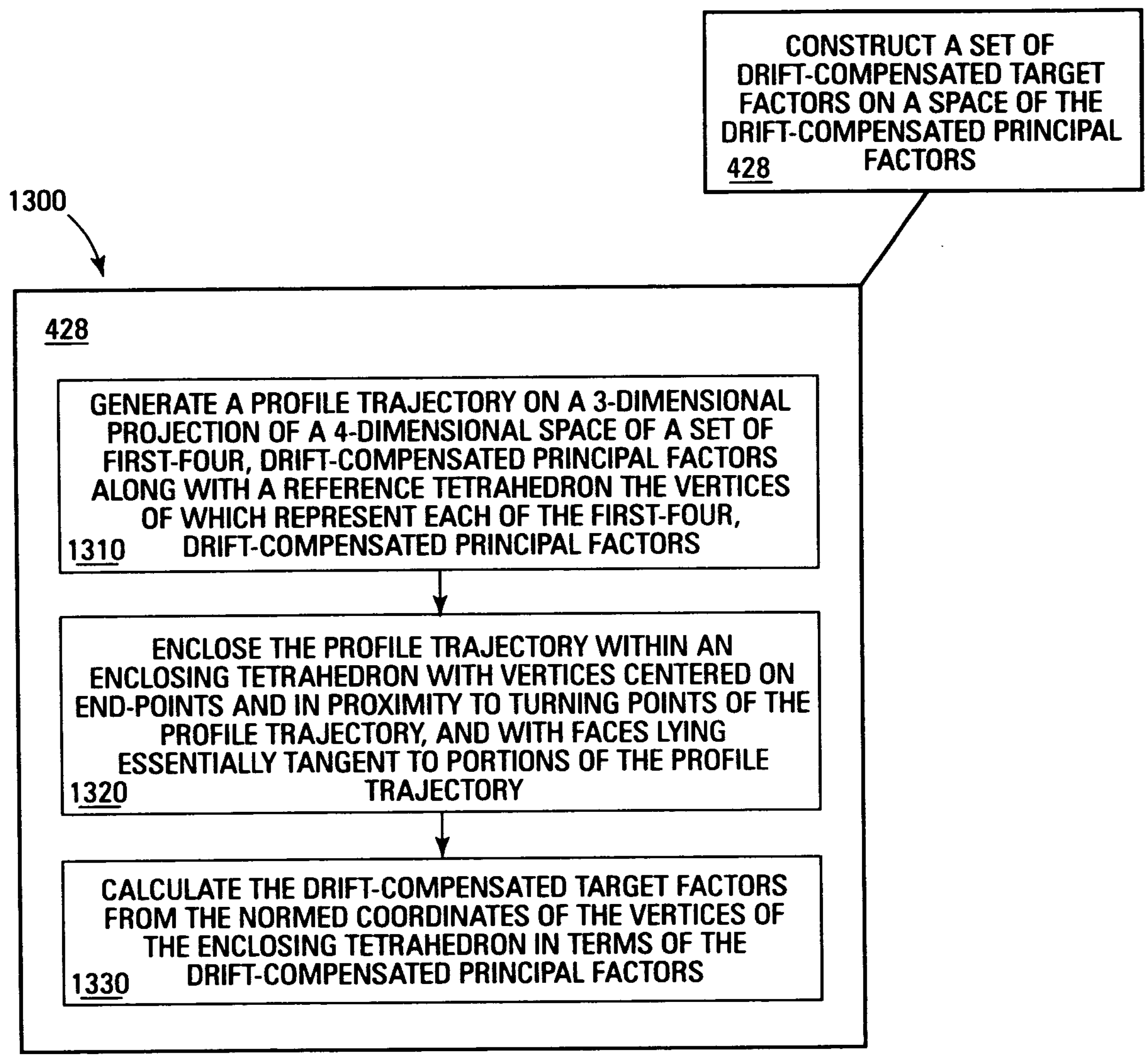

CONSTRUCT A SET OF DRIFT-COMPENSATED TARGET FACTORS ON A SPACE OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS
428
1300
428
GENERATE A PROFILE TRAJECTORY ON A 3-DIMENSIONAL PROJECTION OF A 4-DIMENSIONAL SPACE OF A SET OF FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS ALONG WITH A REFERENCE TETRAHEDRON THE VERTICES OF WHICH REPRESENT EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS
1310
ENCLOSE THE PROFILE TRAJECTORY WITHIN AN ENCLOSING TETRAHEDRON WITH VERTICES CENTERED ON END-POINTS AND IN PROXIMITY TO TURNING POINTS OF THE PROFILE TRAJECTORY, AND WITH FACES LYING ESSENTIALLY TANGENT TO PORTIONS OF THE PROFILE TRAJECTORY
1320
CALCULATE THE DRIFT-COMPENSATED TARGET FACTORS FROM THE NORMED COORDINATES OF THE VERTICES OF THE ENCLOSING TETRAHEDRON IN TERMS OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS
1330

Fig. 13

1310
GENERATE A PROFILE TRAJECTORY ON A 3-DIMENSIONAL PROJECTION OF A 4-DIMENSIONAL SPACE OF A FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS ALONG WITH A REFERENCE TETRAHEDRON THE VERTICES OF WHICH REPRESENT EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS

1400

1310

1410 CALCULATE 4-SPACE COORDINATES OF A PROFILE TRAJECTORY OF DRIFT-COMPENSATED TARGET-FACTOR PROFILES ON A 4-DIMENSIONAL SPACE TO PRODUCE FOUR COORDINATES FOR EACH POINT IN THE PROFILE TRAJECTORY, ONE COORDINATE FOR EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS

↓

1420 REDUCE THE DIMENSIONALITY OF THE COORDINATES OF THE PROFILE TRAJECTORY BY DIVIDING EACH COORDINATE BY A SUM OF ALL FOUR 4-SPACE COORDINATES TO PRODUCE NORMED COORDINATES FOR THE PROFILE TRAJECTORY

↓

1430 PLOT THE NORMED COORDINATES FOR THE PROFILE TRAJECTORY IN A 3-DIMENSIONAL SPACE THE COORDINATES AXES OF WHICH ARE EDGES OF A REFERENCE TETRAHEDRON, THE VERTICES OF WHICH CORRESPOND TO UNIT VALUES FOR EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS IN A MANNER ANALOGOUS TO PLOTTING OF COORDINATES ON A QUATERNARY PHASE DIAGRAM

Fig. 14

ENCLOSE THE PROFILE TRAJECTORY WITHIN AN ENCLOSING TETRAHEDRON WITH VERTICES CENTERED ON END-POINTS AND IN PROXIMITY TO TURNING POINTS OF THE PROFILE TRAJECTORY, AND WITH FACES LYING ESSENTIALLY TANGENT TO PORTIONS OF THE PROFILE TRAJECTORY; AND, CALCULATE THE DRIFT-COMPENSATED TARGET FACTORS FROM THE NORMED COORDINATES OF THE VERTICES OF THE ENCLOSING TETRAHEDRON IN TERMS OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS

1320 & 1330

1500

1320 & 1330

1510 PLACE VERTICES OF AN ENCLOSING TETRAHEDRON AT LOCI OF HEAVY POINT CONCENTRATIONS OF A PROFILE TRAJECTORY

↓

1520 ADJUST THE EDGES OF AN ENCLOSING TETRAHEDRON TO LIE ALONG ESSENTIALLY STRAIGHT LINE SEGMENTS

↓

1530 PLACE REMAINING VERTICES OF AN ENCLOSING TETRAHEDRON SO AS TO LIE NEAR THE TURNING POINTS OF THE PROFILE TRAJECTORY

↓

1540 ADJUST THE FACES OF THE ENCLOSING TETRAHEDRON TO LIE ALONG CURVED SEGMENTS JOINING A TURNING POINT AND ESSENTIALLY STRAIGHT LINE SEGMENTS OF THE PROFILE TRAJECTORY

Fig. 15

1600

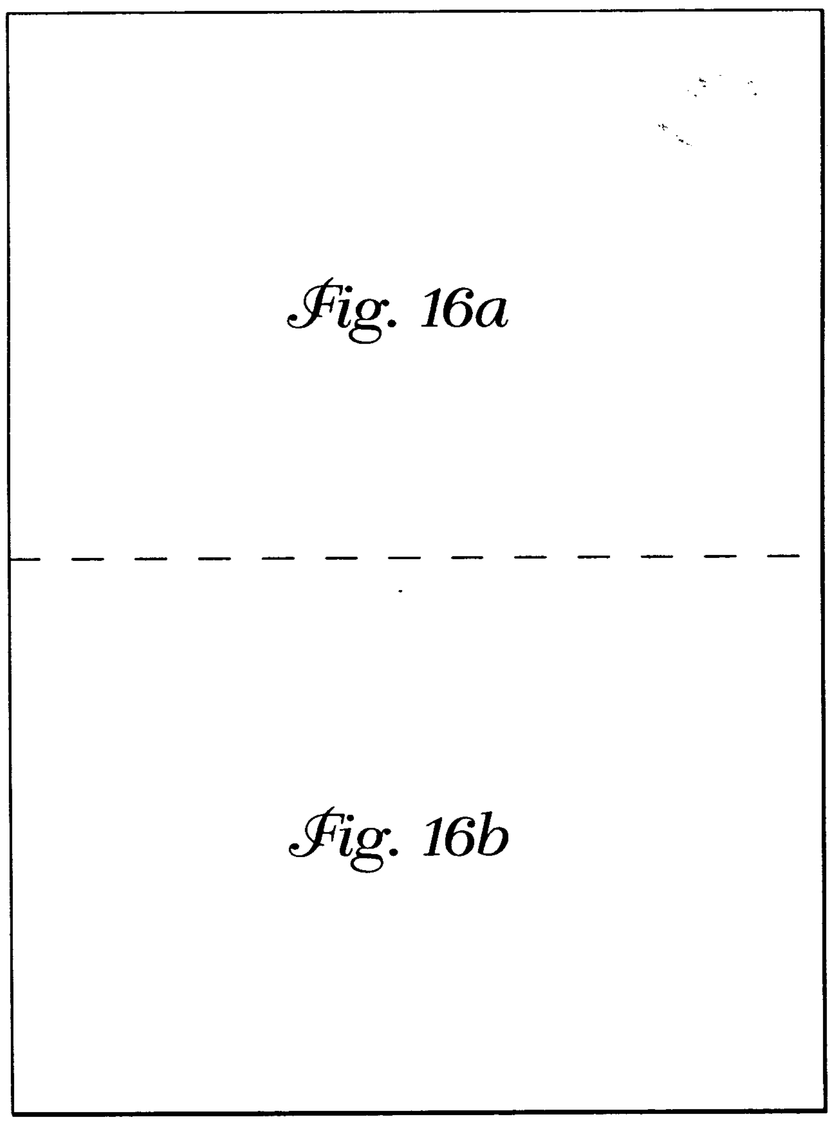


Fig. 16

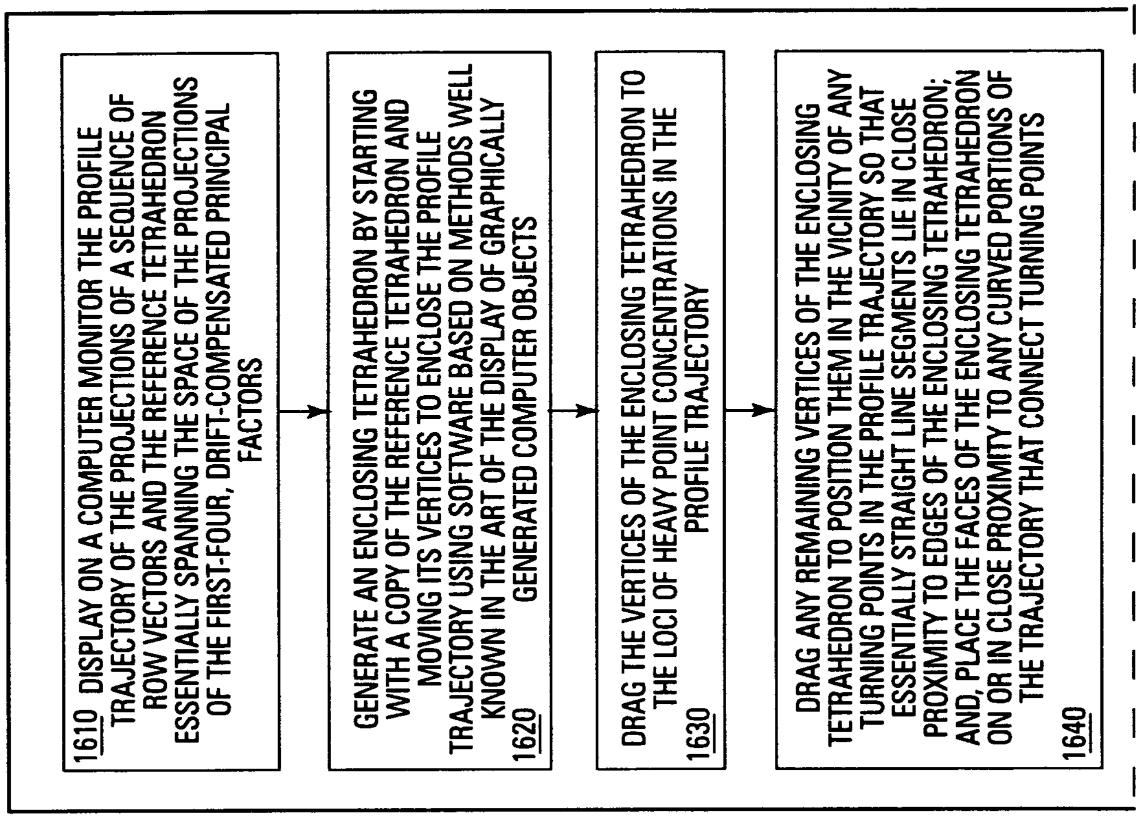

1610 DISPLAY ON A COMPUTER MONITOR THE PROFILE TRAJECTORY OF THE PROJECTIONS OF A SEQUENCE OF ROW VECTORS AND THE REFERENCE TETRAHEDRON ESSENTIALLY SPANNING THE SPACE OF THE PROJECTIONS OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS
GENERATE AN ENCLOSING TETRAHEDRON BY STARTING WITH A COPY OF THE REFERENCE TETRAHEDRON AND MOVING ITS VERTICES TO ENCLOSE THE PROFILE TRAJECTORY USING SOFTWARE BASED ON METHODS WELL KNOWN IN THE ART OF THE DISPLAY OF GRAPHICALLY GENERATED COMPUTER OBJECTS
1620
DRAG THE VERTICES OF THE ENCLOSING TETRAHEDRON TO THE LOCI OF HEAVY POINT CONCENTRATIONS IN THE PROFILE TRAJECTORY
1630
DRAG ANY REMAINING VERTICES OF THE ENCLOSING TETRAHEDRON TO POSITION THEM IN THE VICINITY OF ANY TURNING POINTS IN THE PROFILE TRAJECTORY SO THAT ESSENTIALLY STRAIGHT LINE SEGMENTS LIE IN CLOSE PROXIMITY TO EDGES OF THE ENCLOSING TETRAHEDRON; AND, PLACE THE FACES OF THE ENCLOSING TETRAHEDRON ON OR IN CLOSE PROXIMITY TO ANY CURVED PORTIONS OF THE TRAJECTORY THAT CONNECT TURNING POINTS
1640

Fig. 16a

APPLY MINOR ADJUSTMENTS TO THE LOCATION OF THE VERTICES OF THE ENCLOSING TETRAHEDRON TO ENCLOSE THE SUBSPACE OF THE PROFILE TRAJECTORY WITH A MINIMAL VOLUME THAT BEST FITS THE DRIFT CORRECTED DATA REPRESENTED BY THE PROFILE TRAJECTORY, PROVIDING AN ENCLOSING TETRAHEDRON, THE VERTICES OF WHICH CORRESPOND WITH THE DRIFT-COMPENSATED TARGET FACTORS OF THE ANALYSIS

1650

DEFINE THE NORMED COORDINATES OF THE VERTICES OF THE ENCLOSING TETRAHEDRON RELATIVE TO THE REFERENCE TETRAHEDRON AS THE ENCLOSING-VERTEX WEIGHTING FACTORS USED TO OBTAIN THE DRIFT-COMPENSATED TARGET FACTORS FROM THE NORMALIZED FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS

1660

OBTAIN THE VECTORS GIVING THE DRIFT-COMPENSATED TARGET FACTORS FOR EACH VERTEX OF THE ENCLOSING TETRAHEDRON BY SUMMING THE PRODUCTS OF EACH ENCLOSING-VERTEX WEIGHTING FACTOR WITH THE VECTOR GIVING THE NORMALIZED FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTOR THAT CORRESPONDS TO EACH VERTEX OF THE REFERENCE TETRAHEDRON

1670

Fig. 16b

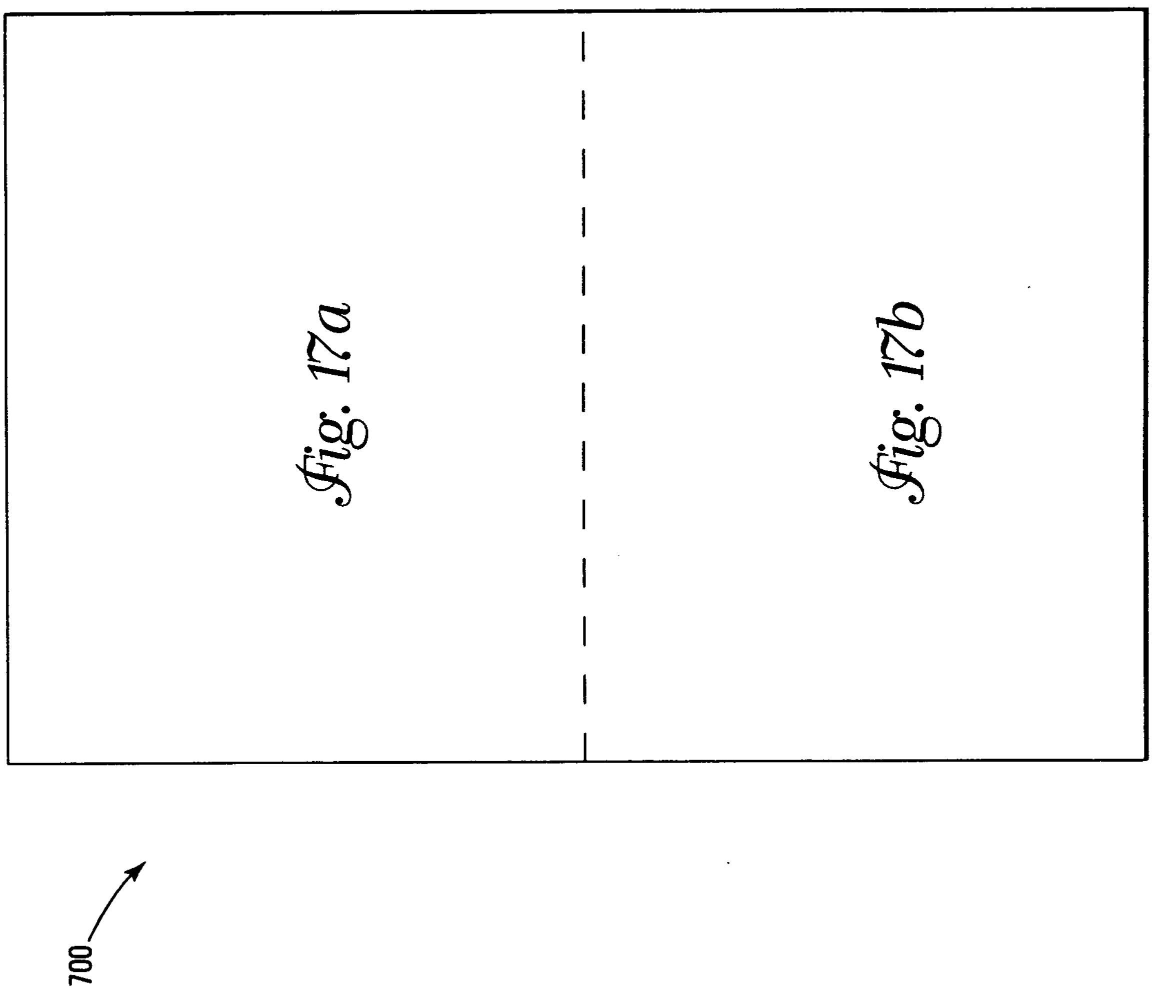


Fig. 17

OUTPUT ANALYTICAL RESULTS SELECTED FROM THE GROUP CONSISTING OF A SET OF DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES DERIVED FROM THE SET OF TARGET-FACTOR WEIGHTING FACTORS, AND THE SET OF DRIFT-COMPENSATED TARGET FACTORS
436

436

1710 OBTAIN THE SET OF DRIFT-COMPENSATED TARGET-FACTOR PROFILE VALUES BY APPLYING THE SET OF DRIFT-COMPENSATED TARGET FACTORS TO THE PROFILE TRAJECTORY BY ASCERTAINING THE NORMED COORDINATES OF EACH POINT ON THE PROFILE TRAJECTORY, I.E. THE TARGET-FACTOR WEIGHTING FACTORS, FROM THE ENCLOSING TETRAHEDRON IN A MANNER ANALOGOUS TO FINDING COORDINATES OF A POINT ON A QUARTERNARY PHASE DIAGRAM

1720 COMPOSE A REFERENCE VECTOR BY SUMMING THE PRODUCTS FROMED BY MULTIPLYING THE VECTORS CORRESPONDING TO THE DRIFT-COMPENSATED TARGET FACTORS BY THE TARGET-FACTOR WEIGHTING FACTORS, FOR EACH POINT ON THE PROFILE TRAJECTORY

1730 SCALE THE AMPLITUDE OF THE RESULTING REFERENCE VECTOR TO OPTIMALLY MATCH THE CORRESPONDING ROW VECTOR COMPENSATED FOR THE EFFECTS OF DRIFT

Fig. 17a

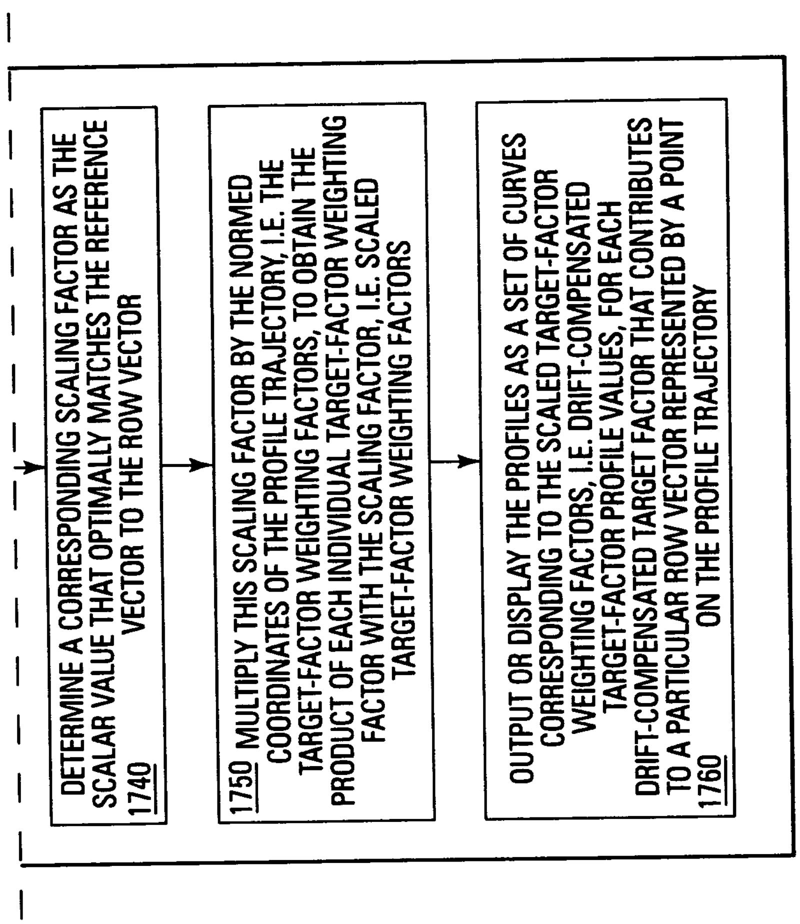

DETERMINE A CORRESPONDING SCALING FACTOR AS THE SCALAR VALUE THAT OPTIMALLY MATCHES THE REFERENCE VECTOR TO THE ROW VECTOR
1740
1750 MULTIPLY THIS SCALING FACTOR BY THE NORMED COORDINATES OF THE PROFILE TRAJECTORY, I.E. THE TARGET-FACTOR WEIGHTING FACTORS, TO OBTAIN THE PRODUCT OF EACH INDIVIDUAL TARGET-FACTOR WEIGHTING FACTOR WITH THE SCALING FACTOR, I.E. SCALED TARGET-FACTOR WEIGHTING FACTORS
OUTPUT OR DISPLAY THE PROFILES AS A SET OF CURVES CORRESPONDING TO THE SCALED TARGET-FACTOR WEIGHTING FACTORS, I.E. DRIFT-COMPENSATED TARGET-FACTOR PROFILE VALUES, FOR EACH DRIFT-COMPENSATED TARGET FACTOR THAT CONTRIBUTES TO A PARTICULAR ROW VECTOR REPRESENTED BY A POINT ON THE PROFILE TRAJECTORY
1760

Fig. 17b

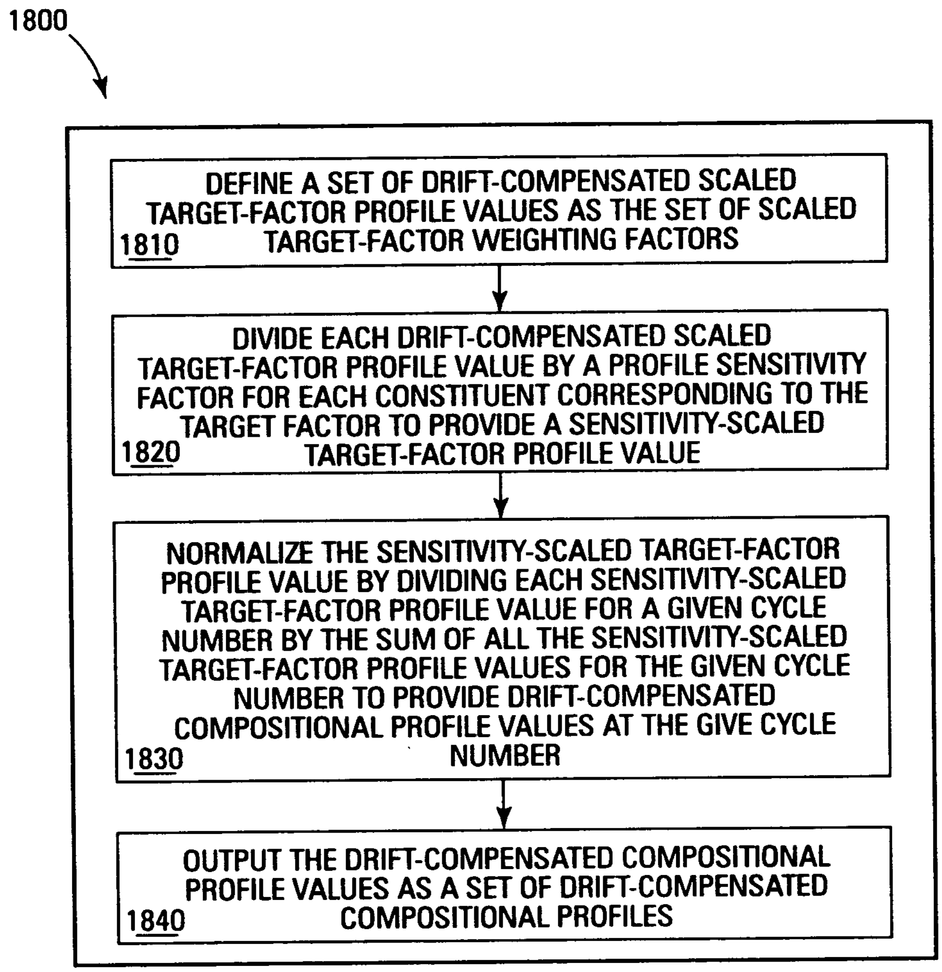

1800
DEFINE A SET OF DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILE VALUES AS THE SET OF SCALED TARGET-FACTOR WEIGHTING FACTORS
1810
DIVIDE EACH DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILE VALUE BY A PROFILE SENSITIVITY FACTOR FOR EACH CONSTITUENT CORRESPONDING TO THE TARGET FACTOR TO PROVIDE A SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUE
1820
NORMALIZE THE SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUE BY DIVIDING EACH SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUE FOR A GIVEN CYCLE NUMBER BY THE SUM OF ALL THE SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUES FOR THE GIVEN CYCLE NUMBER TO PROVIDE DRIFT-COMPENSATED COMPOSITIONAL PROFILE VALUES AT THE GIVE CYCLE NUMBER
1830
OUTPUT THE DRIFT-COMPENSATED COMPOSITIONAL PROFILE VALUES AS A SET OF DRIFT-COMPENSATED COMPOSITIONAL PROFILES
1840

Fig. 18

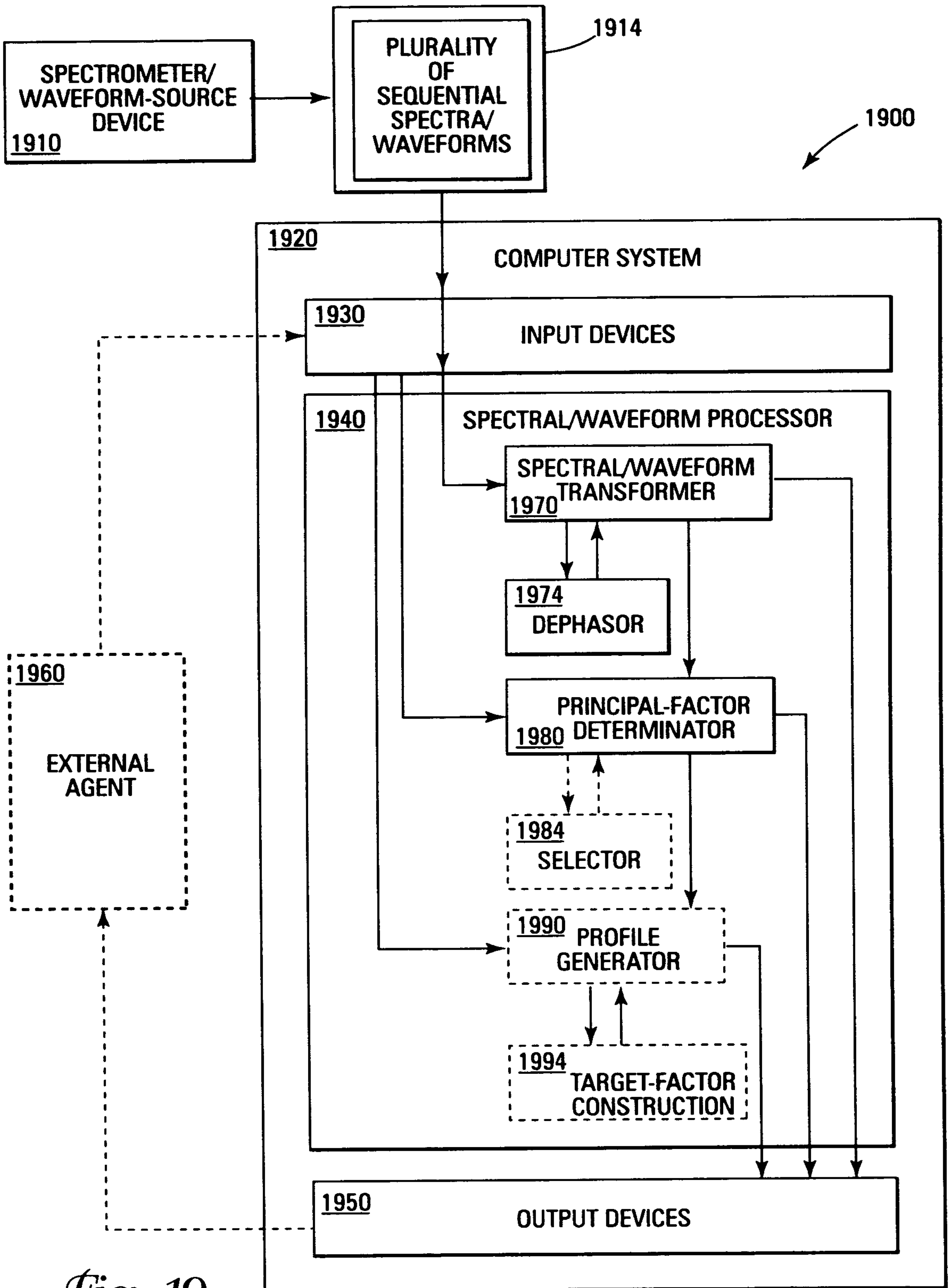

SPECTROMETER/ WAVEFORM-SOURCE DEVICE 1910
PLURALITY OF SEQUENTIAL SPECTRA/ WAVEFORMS
1914
1900
1920
COMPUTER SYSTEM
1930
INPUT DEVICES
1940
SPECTRAL/WAVEFORM PROCESSOR
SPECTRAL/WAVEFORM TRANSFORMER 1970
1974 DEPHASOR
PRINCIPAL-FACTOR DETERMINATOR 1980
1984 SELECTOR
1990 PROFILE GENERATOR
1994 TARGET-FACTOR CONSTRUCTION
1960
EXTERNAL AGENT
1950
OUTPUT DEVICES

Fig. 19

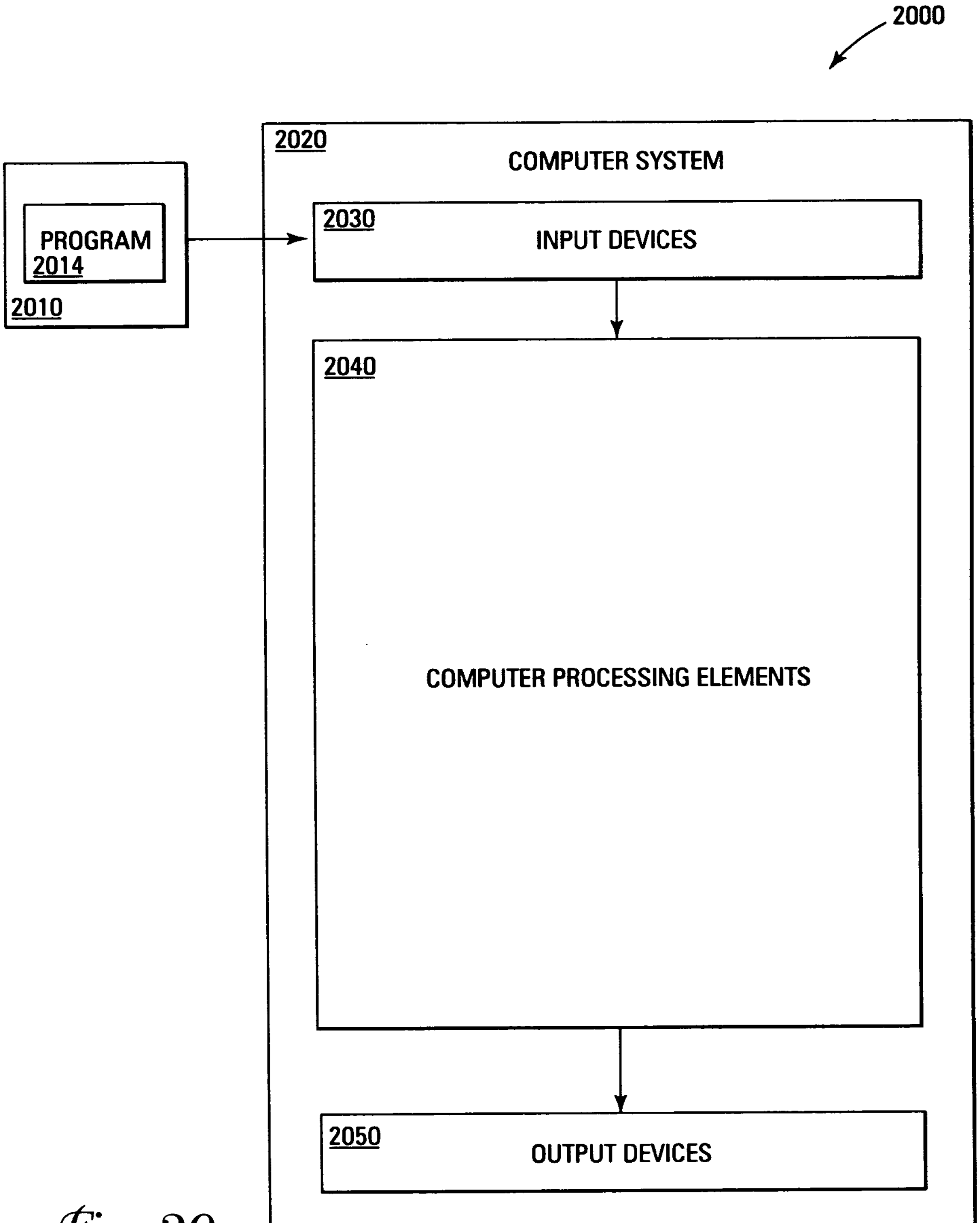

2000
2020
COMPUTER SYSTEM
PROGRAM
2014
2010
2030
INPUT DEVICES
2040
COMPUTER PROCESSING ELEMENTS
2050
OUTPUT DEVICES

Fig. 20